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FISKERIDIREKTORATETS SKRIFTER
Serie Havundersøkelser

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Investigations on Cod Larvae in the Coastal Waters of Northern Norway

Occurrence of cod larvae, and occurrence of food organisms in the stomach contents and in the sea

Preliminary report

by

K. F. WIBORG

1948

A.s John Griegs Boktrykkeri, Bergen

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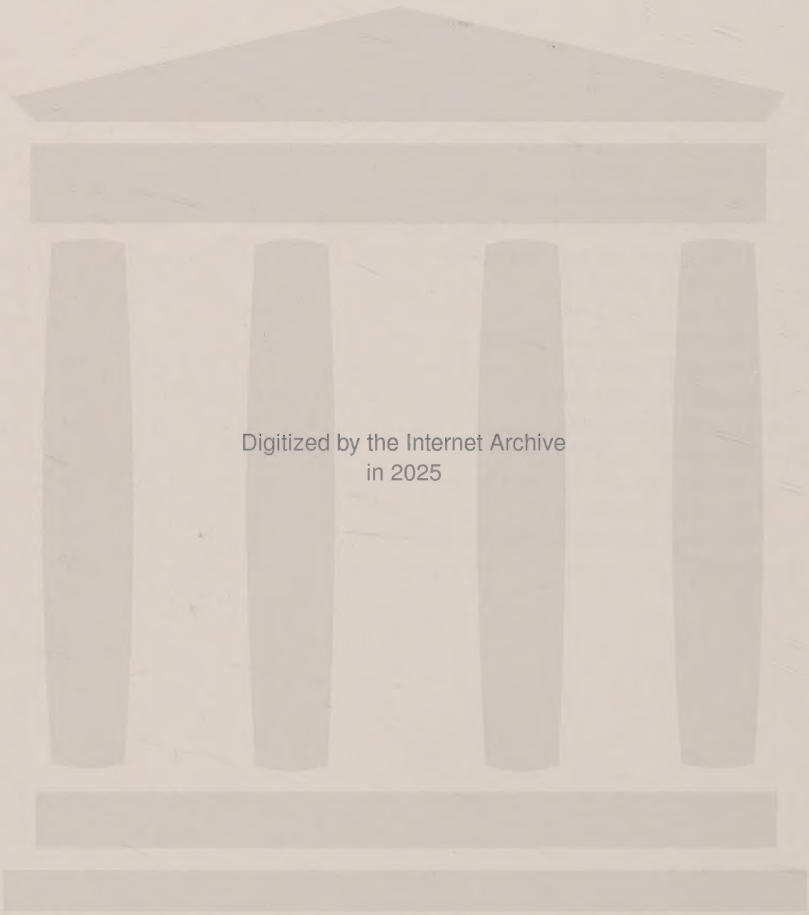
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INTRODUCTION.

It is generally supposed that the variations in size in the stock of various fishes are fixed early in the life history, probably already in the pelagic stage, and that the survival of the broods to a certain extent depends on the quantity of food available for the larvae in the plankton (HJORT 1914). This is surely also the case with the stock of the Arcto-Norwegian cod or »skrei«. The skrei spawns in January—April on the coastal banks of Northern Norway, mainly in the Lofoten area. The eggs are found in great quantities near the surface of the sea from the end of January to the middle of April. Maximum spawning as a rule occurs in the middle of March. Very few larvae are found in the plankton in the Lofoten area until the end of March. The first cod larvae as a rule occur in the plankton samples at the beginning of April. The time of development of the eggs in March in the Lofoten area will be about 18 days. (G. O. SARS 1879). CUNNINGHAM (DAMAS 1909 cit.) states that at a temperature of 3.5 centigrades the time of development is 20 days, at 7 centigrades 12—13 days.

The temperature in the surface layers in the Lofoten area in April is usually 3.5—5.0 centigrades.

The pelagic stage lasts for about three months (HJORT and C. G. JOH. PETERSEN 1905).

MATERIAL AND METHODS.

Samples of zooplankton have been collected in the waters of Northern Norway each year from 1922 and up to now, mainly in spring and summer time.

The greater part of this material has been collected occasionally in the course of other investigations, without any special purpose. The intention is now to work up most of the material, to investigate the occurrence of cod eggs and larvae in the different years and determine the stomach contents of parts of the larvae, further to find out the quantity of food organisms in the sea during the same periods and any possible connection between the occurrence of cod larvae and the number of food organisms present.

The plankton material has been collected partly in horizontal hauls with a 1 meter net, silk No. 0, partly in vertical hauls with a Nansen closing net, diameter 72 centimeters, silk No. 8 in the conical part and No. 0 in the cylindrical part. Some plankton has been sampled with a phytoplankton net, diameter 40 centimeters, silk No. 25. In 1947 plankton was also collected with the Clarke-Bumpus plankton sampler. (See WIBORG 1948 a).

The plankton samples have been preserved in 4 percent formaline.

In the further work the cod larvae as a rule have been counted in the whole sample. Cod eggs and food organisms which were more numerous, have been counted in 1/10—1/100 of the sample according to the quantity of plankton present. The samples were divided by means of LEA's plankton divider. (WIBORG 1940). When the eggs were very numerous, the volume was measured in ml. and the number counted in a small part of it. In the investigation of the stomach content the entire gut was removed and dissected by the aid of thin needles.

This paper deals with material collected in the years 1930, 1933, 1939, 1946 and 1947.

ON THE FOOD OF COD LARVAE.

Already in 1865 G. O. SARS (1879) investigated the stomach contents of cod larvae 7—8 mm of length. He found that they had eaten copepods, chiefly *Calanus finmarchicus* and *Temora longicoruis*.

FABRE-DOMMERGUE et BIETRIX (DAMAS 1909 cit.) find that larvae of soles eat minute plants even before the yolk sack is resorbed.

M. LEBOUR (1918—1920) has made extensive studies on the food of fish larvae of many different species. She states that copepods and other entomostraca constitute the main food of nearly all young fish, and that each species of fish as a rule selects its own favourite food to which it keeps. Even before the yolk sack is resorbed, the gut may contain food.

She says further that the diet of the fish depends to some extent on the size of the mouth and gullet.

As a consequence of this I have measured the mouth openings of some cod larvae of different size in a dorsoventral and a transversal section (fig. 1 and table 1). Only those larvae were used in which the mouth was wide open, because it is difficult to open the mouth in cod larvae preserved in formaline, without injuring the yaws.

It is supposed that the maximum size of the organisms which can be taken in is dependent on the greatest breadth of these organisms. Of the copepods and their larvae it would be the breadth with antennae

and legs laid along the body. In fig. 2 the breadth of the mouth opening of cod larvae of different lengths is compared with the greatest breadth of some copepods and their larvae. (See WIBORG 1948 a).

The yolk sack of the cod larvae is resorbed at a length of 4,5—5.1 mm (DAMAS 1909, and own investigations). From this moment the larvae are dependent on the food available in the plankton.

Several different organisms have been found in the stomachs of cod larvae: Eggs, nauplii and copepodites of *Calanus finmarchicus*, nauplii and eggs of *Metridia spp.* (*longa* et *lucens*), nauplii of *Calanus hyperboreus*,



Fig. 1. Schematic view of the head of a cod larva with the mouth wide open, in order to show how the measurements were taken.

TABLE 1.

Mouth opening of cod larvae of varying size.

Length of the larvae mm	Heigth of mouth opening mm	Breadth of mouth opening mm
4.7	0.41	0.29
4.7	0.29	0.29
4.8	0.36	0.26
4.8	0.43	0.29
4.8	0.43	0.31
5.1	0.48	0.48
5.1	0.38	0.26
5.1	0.36	0.34
5.1	0.60	0.36
5.3	0.47	0.37
6.0	0.40	0.40
6.0	0.52	0.40
6.0	0.60	0.48
6.2	0.60	0.55
6.2	0.48	0.43
6.9	0.83	0.71
7.9	0.66	0.66
9.3	0.80	0.80

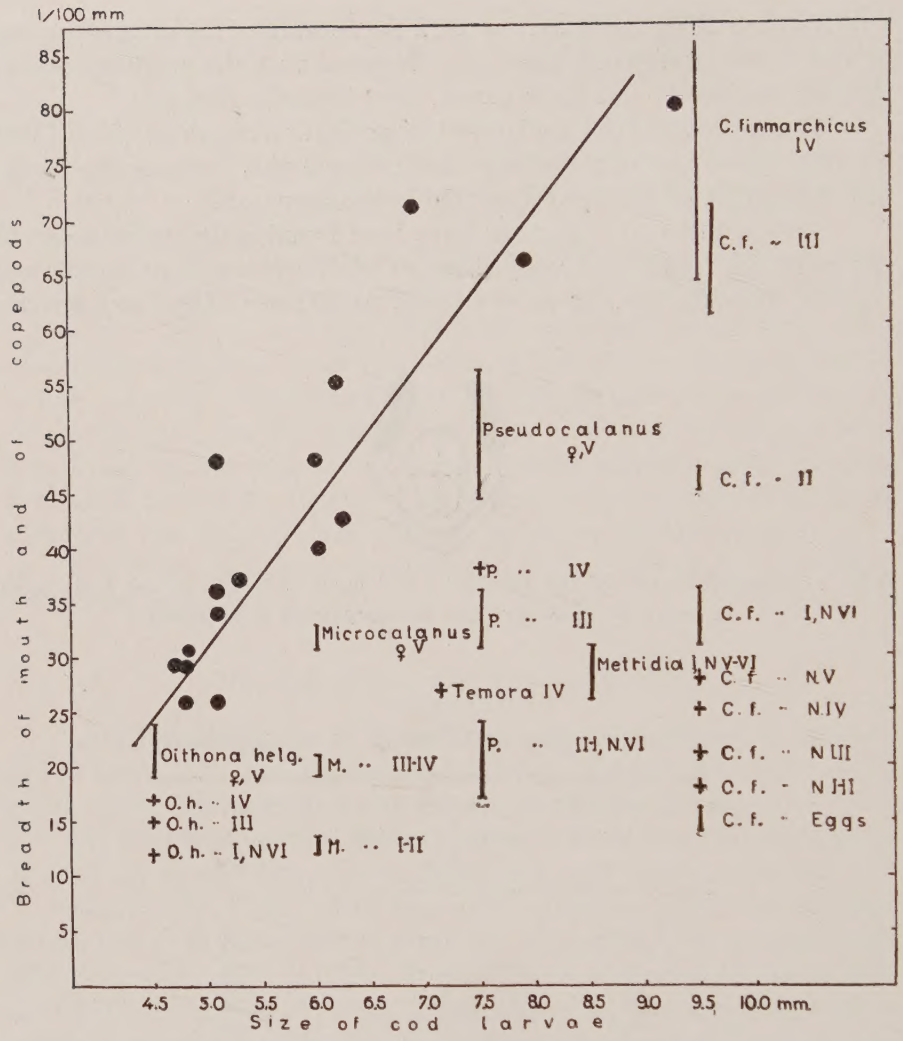

1/100 mm
Breadth of mouth and of copepods
Size of cod larvae
4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0 mm.
C. finmarchicus IV
C. f. - III
Pseudocalanus ♀V
C. f. - II
+P. .. IV
P. .. III
Microcalanus ♀V
C. f. - I, N VI
Metridia I, N V-VI
+ Temora IV
+ C. f .. N V
+ C. f. - N IV
P. .. II-I, N VI
+ C. f. .. N III
+ C. f. - N II-I
C. f. - Eggs
Oithona helg. ♀, V
M. .. III-IV
+ O. h. - IV
+ O. h. - III
+ O. h. - I, N VI
M. .. I-II

Fig. 2. The breadth of the mouth-opening of cod larvae (circles and drawn curve) compared with the greatest breadth of some copepods and their larvae with legs and antennae laid along the body.

adults and larvae of *Temora longicornis*, *Acartia clausi* and *Oithona helgolandica*, and larvae of mussels. The cod larvae keep probably to the food available. It will be shown later to which extent the different organisms are eaten. In a great deal of the cod larvae which just had resorbed the yolk sack or had small remains of it, the stomachs contained some unrecognizable matter, probably similar to what M. LEBOUR calls „green food remains" (M. LEBOUR 1919). It might

be remains of flagellatae or protozoa, or perhaps of appendicularians. Shells of rotatorians have also been met with. — There is also the possibility that it is dissolved matter from the gut itself.

INVESTIGATIONS IN THE LOFOTEN AREA IN 1930.

Occurrence of cod eggs and larvae.

Cod larvae did not occur in the plankton samples until the beginning of April. Fig. 3 shows the localities where cod larvae were found.

In table 2 is shown the occurrence of cod eggs and larvae in the vertical hauls with Nansen 8/72 net in the Lofoten Area in April 1930.

Few larvae are found in the first half of April, and most of them possess a yolk sack. Cod eggs are numerous in the inner part of the West Fjord, but scarce in the outer part.

In the last half of April the larvae are more numerous in the outer fjord with maximum number of 132 larvae at st. 133, but still the majority has not resorbed the yolk sack. It may be, however, that the larger larvae avoid the hauls to a greater extent than do the smaller ones. Cod eggs were scarce during the last half of April.



Fig. 3. Localities for plankton hauls with catch of cod larvae in the Lofoten Area, April 1930.

TABLE 2.

Number of cod eggs and larvae in the hauls with Nansen net 8/72 in the West Fjord. April 1930.

St. No.	Date	Number of cod eggs	No. of larvae			
			With yolk sack	Yolk sack resorbed	Total	Maximum length mm
89	April 5.	3 400	0	3	3	4.5
90	» 5.	4.950	0	3	3	4.0
91	» 7.	1 600	0	1	1	3.7
94	» 7.	1 600	2	0	2	—
107	» 11.	108	3	0	3	—
108	» 11.	69	4	0	4	4.4
115[1]	» 12.	450	4	0	4	—
128[1]	» 24.	few	5	0	5	—
132	» 24	29	2	3	5	—
133	» 24.	150	124	8	132	5.5
134	» 25.	150	27	11	38	—
135	» 25.	16	12	15	27	5.7
136	» 25.	10	0	2	2	4.3
137	» 25.	10	4	0	4	4.0

[1] Phytoplankton net, 25/40.

TABLE 3.

Number of cod eggs and larvae in 5 minutes horizontal surface hauls with the 0/100 net in the West Fjord. April 1930.

St. No.	Date	No. of eggs	No. of larvae
90	April 5.	240 000	0
91	» 7.	30 000	0
94	» 7.	7 200	0
107	» 11.	8 000	39
108	» 11.	2 000	51
114	» 12.	17 200	176
115	» 12.	200 000	1 800
128	» 24.	6 000	23
129	» 24.	4 000	20
130	» 24.	5 200	10
131	» 24.	few	14
132	» 24.	few	1
133	» 24.	30	200
134	» 25.	few	692
135	» 25.	few	30 000[1]
136	» 25.	0	0
137	» 25.	few	42

[1] Apparently ,,dead'' larvae.

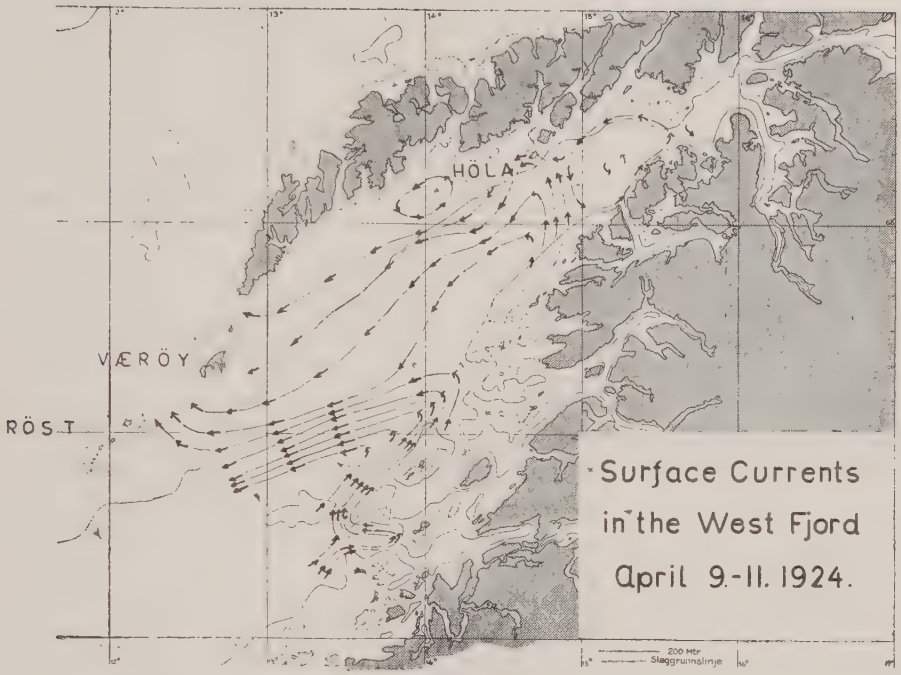


Fig. 4 Surface currents in the Lofoten Area, April 9.—11. 1924.
From Eggvin 1931.

When the hauls were divided, all eggs and larvae were taken in the upper 75—0 meters.

In table 3 is shown the occurrence of cod eggs and larvae in the same period in horizontal surface hauls of 5 minutes duration with a 1 meter net.

A much greater quantity of water is filtered in the horizontal hauls than in the vertical ones, and it is supposed that the greater part of the cod eggs float near the surface.

The quantity of eggs is much larger in the inner fjord than in the outer part. Maximum number is always found at *Høla*.

During the first half of April cod larvae are most numerous in the inner fjord, during the last half of the month in the outer part.

Peculiar is the enormous number of larvae at the outermost station (st. 135). All these larvae were practically dissolved. Only the head with eyes and remains of the body were left. They must probably have been dead before the capture. It cannot have been due to the fixation, for the other organisms in the plankton sample were excellently preserved.

In connection with the distribution of the cod larvae it may be of interest to study the water currents in the West Fjord. Fig. 4 shows the currents in the surface layers in the West Fjord on April 9.—11. 1924. (From Eggvin 1931). Dr. Eggvin has told me that this chart may be considered as representative for the currents in the upper 50 meters in the West Fjord in the different years, allthough minor differences may occur.

The speed of the current is approximately 9 cm/sec. Along the Northern side there is a steady current going out of the fjord. This current will carry along some of the cod eggs spawned in the inner fjord, and larvae hatched in the same area. (An eddy is found on the banks near Høla, and in the innermost part of the fjord).

About three weeks will be needed to carry cod eggs with the water current from the inner fjord to the outermost part. The currents pass between the outermost islands and go northwards along the coast. Eggs and larvae of the cod may in this way be carried far away from the spawning places. (See also Hjort 1905).

Stomach contents.

Of 694 cod larvae examined from the 1930 material 168 possessed a big yolk sack and 76 were defect. The remaining 450 larvae had resorbed the yolk sack fully, or had only small remains of it. 168, or 40 per cent of these larvae had stomach contents.

The result of the investigations is shown in table 4. The number

TABLE 4.

Stomach contents of cod larvae in the Lofoten Area. April 1930.

	Number of larvae in which the different food organisms are found			
	Length groups, mm			Total
	3.1—5.0	4.8—6.0	6.5—	
Number of larvae examined	161	16	1	178
Calanus finmarchicus copepodite st I...	1	—	—	1
Calanus and *Metridia* nauplii	71	13	—	84
Acartia nauplii	1	—	—	1
Oithona helgolandica copepodites	4	1	1	6
—»— nauplii	13	1	—	14
Eggs of copepods (*Calanus, Metridia*) ..	25	—	—	25
Uncrecognizable stomach contents	81	5	1	87

TABLE 5.

Number of some plankton organisms in the 75—0 meter haul with Nansen 8/72 net at some stations in the Lofoten Area. April 1930.

Species	St. 90 April 5.	St. 107 April 11.	St. 115[1] April 12.	St. 132 April 24.	St. 135 April 25.
Calanus finmarchicus, nauplii	2 500	2 350	2 400	4 900	450
—»— eggs	2 300	1 000	1 500	—	—
Calanus hyperboreus, nauplii ..	1 300	700	300	300	—
Metridia spp., nauplii	400	500	—	—	50
—»— eggs	1 400	800	100	—	—
Oithona helgolandica, adults and larvae	700	450	50	—	200
Total	8 600	5 800	4 350	5 200	700

[1] Phytoplankton net 25/40.

of larvae which have eaten the different organisms is stated. One larva may contain more than one species.

The majority of the larvae examined were very small, from 3.1—5.0 millimeters of length. The measurements will not give a quite reliable picture of the lengths, because many larvae are shrunk or curved and therefore difficult to measure.

Nearly half of the larvae had some unrecognizable matter in the gut. It may be remains of protozoa, flagellates or other organisms. In some cases it was supposed to be rotatorians, appendicularians or polychaete larvae.

Among the organisms which could be determined, nauplii of *Calanus finmarchicus* were predominant, occurring in about half of the larvae. Eggs of *Calanus finmarchicus* and of *Metridia* spp. range second, and next come copepodites and larvae of *Oithona* spp., mainly *O. helgolandica*.

The vertical hauls with the Nansen net will not give a reliable picture of the copepod population as a whole (Wiborg 1948 a), the bigger copepods being caught to a greater extent than the smaller ones, and part of the smallest organisms — some of these also being food organisms of the cod larvae — passing through the meshes of the net. But the hauls will nevertheless give an impression of the quantity of food organisms available.

Table 5 shows the number of nauplii and eggs of *Calanus* and *Metridia*, and adults and larvae of *Oithona* spp. at some stations in the West Fjord in April 1930.

There is about the same number of food organisms at most of the

stations, but comparatively few at station 135 in the outer fjord. It will be remembered that a considerable number of apparently dead cod larvae were found in the surface hauls at this station.

INVESTIGATIONS IN 1933.

Occurrence of cod larvae.

In 1933 a material of fish larvae was collected in the period May 22. —June 7. Horizontal hauls with a 1 meter net were made at different depths in the coastal areas of Northern Norway, mainly in Lofoten and Finmarken. The nets were towed for 15 minutes. They were not closing nets, and may therefore catch both while being set and when hauled up. But the bulk of the catch is taken in said depth.

Fig. 5 shows the localities for the hauls and table 6 the numbers of cod larvae caught in the different hauls. The majority of the larvae were taken at the stations north of Lofoten, and then mostly in the deeper hauls.

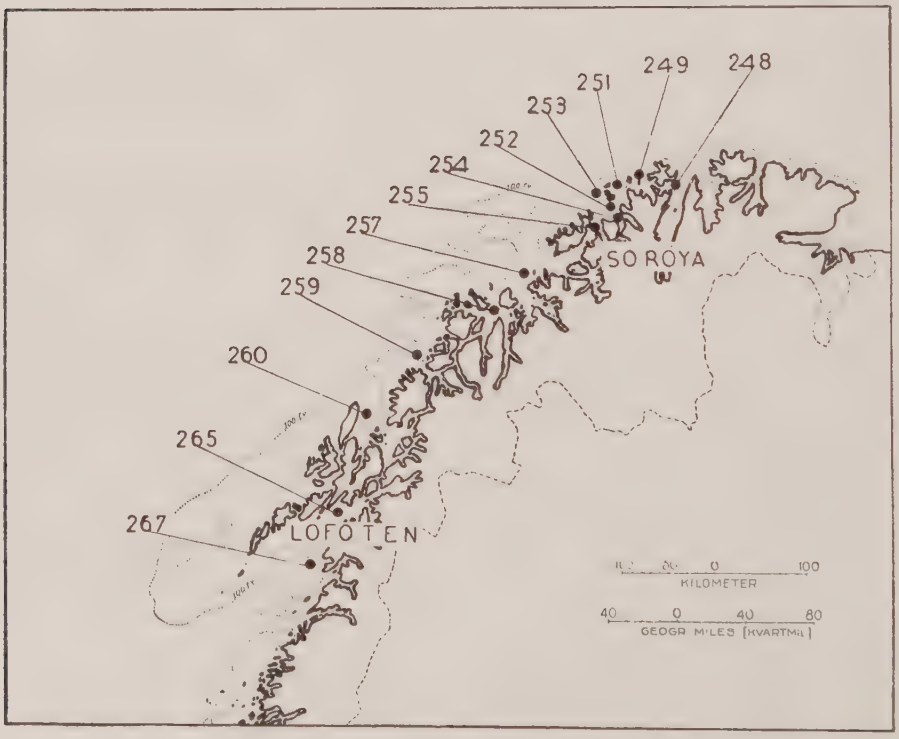


Fig. 5. Localities for plankton hauls with catch of cod larvae in the coastal area of Northern Norway, May—June 1933.

TABLE 6.

Number and size of cod larvae along the coast of Northern Norway, caught in 15 minutes horizontal hauls with a 0/100 net. May—June 1933.

St. No.	Date	Wire out, m	Approximate depth m	No. of larvae	Length variation mm	Average lengths, mm	
248	May 22.	0	0	9	—	—	—
249	» 22.	0	0	0	—	—	—
251	» 22.	0	0	59	—	—	—
253	» 23.	100	40	66	—	—	—
252	» 23.	250	100	51	3.5—11.0	7.85	
		175	70	53	4.5—13.5	8.4	8.12
254	» 23.	200	80	180	5.0—12.5	7.92	
		150	60	186	4.0—13.0	7.8	7.84
		100	40	92	4.5—11.0	7.6	
255	» 24.	400	160	220	4.5—13.0	7.5	
		200	80	238	4.0—13.5	6.9	7.32
		100	40	118	5.0—11.5	7.46	
257	» 24.	200	80	152	5.0—12.5	8.67	
		125	50	113	3.5—11.5	7.37	8.02
		75	30	38	4.0—12.5	7.63	
258	» 24.	200	80	288	4.0—14.0	7.64	7.61
		100	40				
		50	20	20	3.5—10.0	7.18	
259	» 29.	200	80	34	5.0—11.0	7.16	
		100	40	9	5.0—10.5	8.9	7.1
		50	20	12	4.0—11.5	6.37	
260	» 30.	200	80	20	5.5—12.5	8.33	
		100	40	28	5.5—15.5	8.84	8.24
		50	20	18	6.0—8.5	7.2	
265	June 1.	75	30	83	5.0—13.5	7.1	
		25	10	51	5.0—11.5	6.49	6.83
267	» 1.	150	60	74	6.0—12.0	8.47	
		100	40	99	5.0—12.5	7.85	7.87
		50	20	50	4.0—11.5	7.64	

Most of the larvae were measured as to length (table 6). A greater number of large larvae were found in the deeper hauls, but both small and large larvae occur in all hauls. According to Dannevig (1925) cod larvae hatched in April at Flødevigen measure 7 millimeters 19 days old, 9 mm — 24 days, and 12 mm — 38 days. The temperature is not mentioned, but it is probably higher than in the coastal areas of Northern Norway.

Stomach contents.

The stomach contents have been investigated in about 130 larvae (table 7). The majority of the specimens examined measured 6.5—9.0 millimeters, a few 10—13 millimeters. They were bigger than the larvae from the Lofoten Area in April 1930, and their diet was also more varied. Most part of the larvae had eaten adults and larvae of *Oithona helgolandica*. Next come copepodites of *Calanus finmarchicus*. Nauplii of *Calanus* and *Metridia* were scarce. Other organisms found in the stomachs were eggs of *C. finmarchicus* and of *Metridia* spp., copepodites and adults of *Pseudocalanus minutus*, *Acartia clausi* and *Temora longicornis* — and *Evadne nordmanni*.

The stomach contents of 30 cod larvae from one station were counted as a whole. (Table 8, not included in table 7). The same organisms as mentioned above are found, with the exception of *Temora*, *Acartia* and copepod eggs.

Vertical hauls were made at two stations in the same area. The number of the most important food organisms found is shown in table 9.

TABLE 7.

Stomach contents of cod larvae in the coastal Area of Northern Norway, May—June 1933.

	Number of larvae in which the different food organisms are found.			
	Length groups, mm			Total
	4.7—6.5 mm	6.5—9.0 mm	10.0—13.0 mm	
Number of larvae examined	5	81	17	103
Calanus finmarchicus:				
Copepodite stage I—IV ...	—	18	6	24
Calanus and *Metridia spp.:*				
Nauplii	—	8	—	8
Eggs	—	9	—	9
♀♀ and cop. stage II—V	1	2	2	5
Temora longicornis, copepodites	—	1	—	1
Acartia clausi, ♀♀ and cop. st.V	—	5	—	5
Oithona helgolandica:				
Adults and copepodites	—	37	10	47
Nauplii	2	33	4	39
Evadne nordmanni	3	—	—	3
Larvae of mussels	—	9	—	9

TABLE 8.

Stomach contents of 30 cod larvae, 4.7—6.5 mm from st. 225 May 24. 1933, approximate depth 160 meters.

		Per 10 larvae
Calanus finmarchicus, copepodite stage I—III	4	1.3
Calanus and *Metridia* spp., nauplii	7	5.7
Pseudocalanus minutus, copepodites	3	1.0
Oithona helgolandica, adults and copepodites	3	1.0
Nauplii	21	7.0
Evadne nordmanni	3	1.0
Larvae of mussels	1	0.3
Total	52	17.3

TABLE 9.

Number of some plankton organisms in the 75—0 meter haul with Nansen 8/72 net at two stations in Northern Norway, May 24. and 29. 1933.

	St. 256	St. 259
Calanus finmarchicus:		
♂	—	150
♀	—	350
V	3 400	3 700
IV	4 200	3 650
III	9 900	2 600
II	4 900	350
I	2 200	200
V—I	24 600	10 500
Nauplii	1 900	250
Pseudocalanus minutus:		
Adults	200	650
Copepodites	4 700	1 100
Nauplii	200	—
Metridia longa et *lucens:*		
Copepodites	1 200	1 400
Nauplii	300	—
Acartia clausi:		
Adults and copepodites	—	850
Nauplii	—	150
Oithona helgolandica:		
Adults and larvae	5 300	1 600
Larvae of mussels	2 400	100
Food organisms B (small)	14 600	3 200
Food organisms A (large)	26 000	13 300

According to the organisms present in the stomachs of cod larvae I have divided the food organisms into two groups: *A* consisting of the largest organisms found, of about the size of *Calanus finmarchicus*, copepodite stage I—IV, and *B* consisting of organisms of the same size or smaller than the nauplius stage VI of *C. finmarchicus*. The group B is still as numerous as in the vertical hauls in the Lofoten Area in April 1930.

INVESTIGATIONS IN 1939.

Very few cod larvae were found during the period of investigations, which stretched from January to about the middle of April.

Table 10 shows the number of cod eggs and larvae in the vertical hauls at the stations in the Lofoten Area.

The stations are all located in the middle of the Lofoten Area. (Fig. 6).

Only on one occasion, a somewhat greater number of larvae, viz. 33, were caught at st. 131 on April 17. Together with the larvae was also a considerable number of eggs.

Most of the larvae investigated in 1939 possessed a yolk sack and had no stomach content. A few larvae had eaten nauplii of *Calanus finmarchicus*, eggs of *Metridia* spp., copepodites and nauplii of *Oithona helgolandica* and nauplii of *Pseudocalanus*.

The number of food organisms of group B (small) at some stations in the Lofoten Area in April 1939 is shown in table 11. There was an abundance of food for the cod larvae.

TABLE 10.

Number of cod eggs and larvae in hauls with Nansen net 8/72 in the West Fjord. April 1939.

St. No.	Date	Locality	Number of cod eggs	Number of cod larvae		
				With yolk sack	Resorbed yolk sack	Total
233	April 4.	Outer fj.	214	1	0	1
235	» 4.	—»—	15	1	0	1
238	» 5.	Inner fj.	179	2	2	4
246	» 5.	—»—	1450	0	0	0
277	» 17.	—»—	600	33	0	33
278	» 17.	—»—	16	1	0	1
279	» 17.	—»—	107	1	0	1

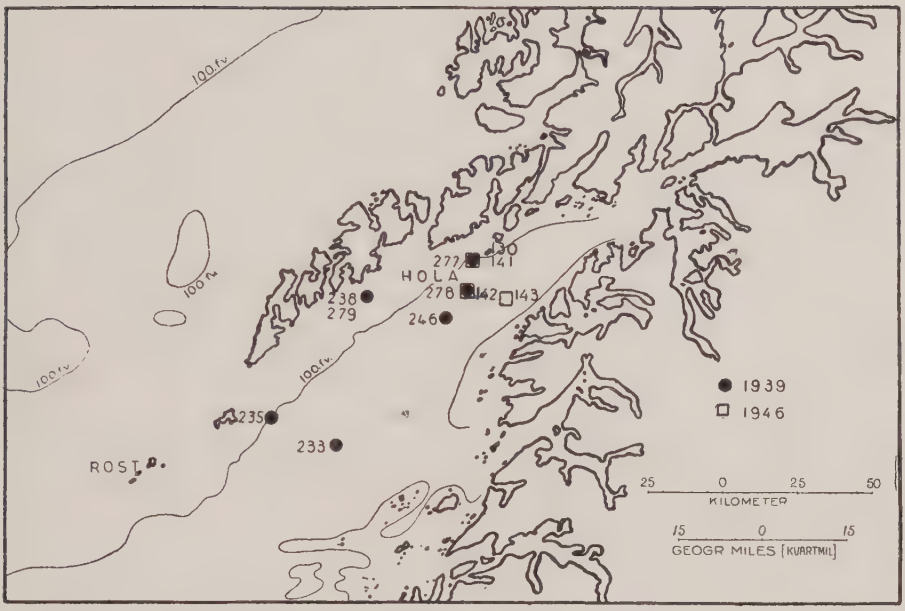


Fig 6. Localities for plankton hauls with catch of cod larvae in the Lofoten Area, April 1939, and April 1946.

TABLE 11.

Number of some plankton organisms in hauls with Nansen 8/72 net in the Lofoten Area. April 1939.

St. No.	235	238	246	277	278	279
Calanus finmarchicus:						
A. Cop. IV—I	600	25	50	1 900	300	2 414
B. Eggs and nauplii	5 700	2 650	5 200	16 900	950	6 700
Pseudocalanus minutus:						
A. Adults	—	5	—	—	—	—
B. Copepodites and nauplii	50	75	200	50	20	—
A. *Metridia* copepodites	75	10	—	—	—	—
B. *M.* nauplii and eggs	350	950	950	200	150	250
Oithona helgolandica:						
B. Adults and larvae	300	1 050	550	300	50	—
Calanus hyperboreus:						
A. Cop. I—II and N VI	625	90	2 750	2 700	110	79
B. Nauplii V—I	—	40	300	—	—	100
Total of large organisms „A"	1 300	130	2 800	4 650	410	2 493
Total of small organisms „B"	6 400	4 695	7 200	17 450	1 170	7 050

INVESTIGATIONS IN 1946.

Great quantities of eggs were found in the Lofoten Area in the last half of March and first half of April, both in the vertical and horizontal hauls. A maximum number of about half a million of cod eggs was caught in one 5 minutes haul at the surface. But no cod larvae were found until April 6., when 1 larva with yolk sack was captured in the 75—0 meter haul at st. 131 (Chart, fig. 6). On April 10., 7 specimens were taken in the surface haul at st. 142, and 54 larvae in the surface haul at st. 143. This station is situated at Hola in the inner fjord where, as a rule, the greatest number of cod eggs and larvae are found.

Of the 54 larvae 31 had resorbed the yolk sack. Only 3 larvae had food in the stomachs, *Oithona* and *Metridia* nauplii, and some diffuse matter.

The investigations ceased on April 10.

The number of small food organisms (*B*) in the 75—0 m haul at st. 141 was 3850, 2/3 of which was nauplii and eggs of *Calanus finmarchicus*.

INVESTIGATIONS IN 1947.

Occurrence of cod larvae.

This year the occurrence of the cod larvae and their food organisms was investigated more thoroughly.

Plankton was collected mainly in vertical hauls with the Nansen net, but some samples were also taken with a plankton pump and with the Clarke-Bumpus plankton sampler.

Two separated cruises were made in the Lofoten Area, one from the beginning of February to the end of March, and one from the middle of April to the middle of May.

No cod larvae were found on the first cruise.

On the second cruise two series of stations were worked from the outer to the inner part of the West Fjord, (Chart, fig. 7), one series in the last half of April and another series in the first week of May. The number of cod eggs and larvae taken in the vertical hauls at these stations is shown in table 12.

In the first series the number of cod larvae varied from 7 at st. 111 in the outer fjord to 42 at st. 116. Very few larvae were found inside st. 116. Of the larvae 71 per cent possessed a yolk sack.

There was a maximum number of eggs at the stations in the middle of the fjord. Few eggs were found inside st. 115.

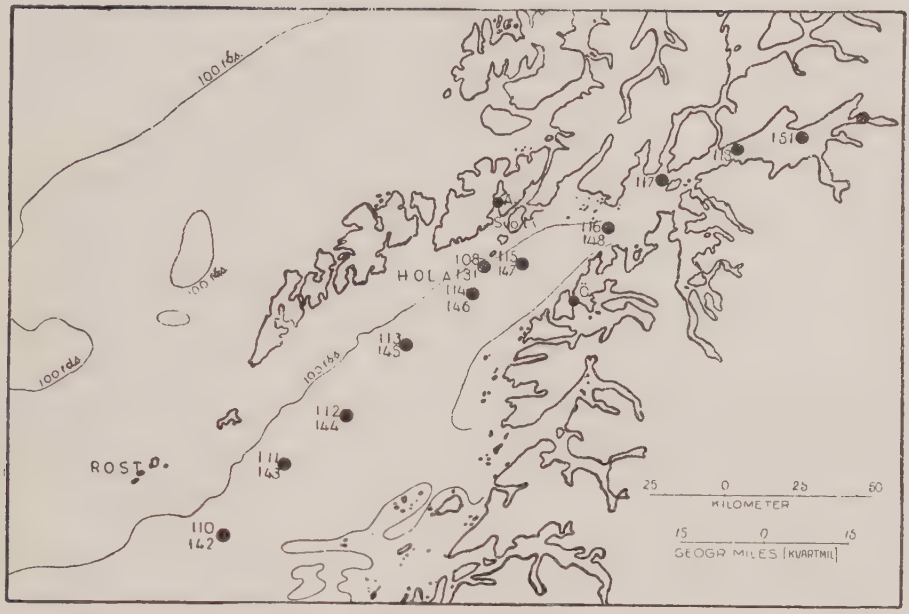


Fig. 7. Localities for plankton hauls with catch of cod larvae in the Lofoten Area, April—May 1947.

In the second series of observations no larvae were found at the two outermost stations. The greatest numbers occur at st. 144—146 in the outer part of the fjord. Of the larvae 80 per cent had now resorbed the yolk sack. Eggs were scarce. The total absence of larvae at st. 148 (Tranøy) must possibly also be ascribed to the current system of the fjord which has carried the larvae in an outward direction.

At all stations few larvae occurred below 50 meters. In the second series of observations the bulk of the larvae was taken in the upper 25—0 meter haul.

At station 131, at Høla, a considerable number of larvae was taken on May 5. The bulk of these still possessed a yolk sack.

A series of observations was made with the plankton sampler in the Austnes Fjord (A), in the Økssund (Ø), and near Skråva (st. 141, same locality as st. 108). At some of the stations vertical hauls were made with the Nansen closing net.

The number of cod eggs and larvae caught at these stations are shown in table 13. For the hauls with the plankton sampler the numbers are given per cubic meter of sea water.

In the Austnes Fjord the bulk of the larvae occur between 10 and 30 meters. At st. 124 the larvae seem to be evenly distributed between

TABLE 12.

Number of cod eggs and larvae in hauls with Nansen net 8/72 in the West Fjord. April—May 1947.

St. No.	Date	No. of eggs	No. of larvae			Maximum length mm
			with yolk sack	yolk sack resorbed	Total	
110	April 24.	1	0	0	0	—
111	» 24.	93	4	3	7	5.8
112	» 25.	94	8	0	8	5.1
113	» 25.	217	5	3	8	6.0
114	» 25.	175	14	8	22	6.0
115	» 25.	19	2	2	4	4.6
116	» 25.	3	32	10	42	6.4
117	» 25.	3	1	0	1	—
118	» 25.	0	0	1	1	5.4
	Total	605	66=71%	27=29%	93	
142	May 7.	0	0	0	0	—
143	» 7.	0	0	0	0	—
144	» 8.	6	6	7	13	5.9 (7.8)
145	» 8.	0	5	20	25	5.8 (6.7)
146	» 8.	1	0	16	16	5.8
147	» 8.	2	0	2	2	6.0
151	» 8.	0	0	1	1	6.9
	Total	9	11=20%	45=80%	56	
108	April 22.	126	9=90%	1=10%	10	5.0
131	May 5.	2	62=82%	14=18%	76	6.1

10 and 30 meters, whereas at st. 123 very few larvae were captured below 25 meters. In the Okssund the majority of the larvae were taken in the haul at 25 meters. The oblique hauls show average values. All the hauls were made in daytime, but according to RUSSELL (1928) there is little change in the vertical distribution of most species of fish larvae during day and night.

The oblique hauls allow us to give the number of cod larvae below one square meter of surface. E.g. at st. 123 there will be 350 larvae, at st. 125 : 600 larvae and at st. 141 : 380 larvae below one square meter of surface.

The number of eggs decreased greatly in the hauls from April 23. to May 6.

TABLE 13.

Number of cod eggs and larvae at some localities in the Lofoten Area, April—May 1947. Plankton sampler hauls per cubic meter of sea water, and Nansen net 8/72, per haul.

Locality		Austnes Fjord						Økssund		Skråva	
Date		April 23		April 30		May 2		May 3		May 6	
No. of silk used		2		2		11		8		2	
Gear	Depth m	Eggs	Larvae	Eggs	Larvae	Eggs	Larvae	Eggs	Larvae	Eggs	Larvae
	1	—	—	—	—	—	—	3.6	—	—	—
	5	35	1	—	—	—	—	—	—	—	—
	10	83	17	27	24	5	17	4.7	1.4	—	—
Plankton	12	—	—	—	—	—	—	—	—	8	17
	15	—	—	—	—	7	14	—	—	—	—
sampler	20	—	—	—	—	14	23	—	—	—	—
	25	44	10	5	1	11	4	3	43	1	2
per	30	—	—	3	1	1	12	—	—	—	—
	38	—	—	—	—	3	3	—	—	—	—
1000 liters	50	3	0	0	0	—	—	0	1	0.3	0.3
	60	—	—	1	0	—	—	—	—	—	—
	75	0	0	—	—	—	—	—	—	0	0
	100	—	—	0	0	—	—	0	0	0	0
	150	—	—	—	—	—	—	0	0	0	0.2
	25—0	—	—	10	13	—	—	12	6	1	10
	50—25	—	—	0	1	—	—	0	17	0.5	2
	100—50	—	—	1	0	—	—	0	0	0	0.5
	150—100	—	—	—	—	—	—	0	0.5	0	1.1
	425—150	—	—	—	—	—	—	0	0	—	—
	25—0	113	13	35	21	—	—	9	15	—	—
Nansen	50—25	32	3	2	3	—	—	0	2	—	—
net	100—50	3	0	1	1	—	—	0	3	—	—
8/72	150—100	—	—	—	—	—	—	0	1	0	0.5
	425—150	—	—	—	—	—	—	0	2	—	—
Total number of eggs and larvae in all hauls		510	73	177	127	36	64	64	137	22	99
No. of larvae with yolk sack resorbed		19 (26%)		43 (34%)		32 (50%)		46 (34%)		41 (41%)	

The number of cod eggs and larvae taken in the vertical Nansen net hauls at the same stations are of about the same order of size as those taken with the plankton sampler.

Stomach contents.

Of 304 cod larvae investigated, 193 possessed a yolk sack or had small remains of it. 11 of these larvae had stomach contents. Of the remaining 112 larvae, 78 (70 per cent) had food in their stomachs.

The stomach contents have been closer investigated in 80 larvae from all stations. Most of them had just resorbed the yolk sack and were of lengths from 4.0—5.7 mm. (Table 14).

Half the number had unrecognizable stomach content. The others had most exclusively eaten nauplii of *Calanus finmarchicus*. Two of the biggest larvae had eaten copepodites of stage I of *C. finmarchicus*.

On the food organisms in the sea.

In table 15 is given the number of food organisms in the 50—0 meter hauls at the stations in the West Fjord. As previously the organisms are divided into two groups, large and small (see page 18).

There seems to be a considerable quantity of food organisms of both cathegories in all parts of the West Fjord in April and May 1947. As a rule the majority of the small food organisms is found in the upper 25 meters, but at some stations in the middle of the fjord there is a greater number below 25 meters. It is assumed that these are found in the water layers immediately below 25 meters and above 50 meters.

At the st. 117—118 in the inner fjord, the number of food organisms were small, and also few cod larvae were found.

Table 16 shows the number of food organisms taken in the plankton sampler in the Austnes Fjord. For comparison is set up the number of food organisms taken in vertical hauls with the Nansen net.

There is a considerable quantity of food for the cod larvae in the upper water layers down to 50 meters depth.

The cod larvae in the Austnes Fjord numbered usually 10—20 per cubic meter of sea water in the water layer between 10 and 25 meters, or one larvae per 50—100 liters of water. The number of small food organisms varies between 5000 and 25.000 per cubic meter in the same water layer, or 5—25 organisms per liter. Inside a sphere with radius 6.4 cm the cod larvae will likely find from 5—25 suitable food organisms.

The stomachs of the smallest cod larvae as a rule contain 1—5 food organisms, seldom more.

The time taken to digest the food is not known. In pelagic larvae of plaice it takes at least 6 hours to digest the food in the stomach. If corresponding values are found for the cod larvae, one larva should need from 4—20 food organisms each 24 hours, on the assumption that

TABLE 14.

Stomach contents of cod larvae in the Lofoten Area. April—May 1947.

Stomach contents	Number of larvae in which the different food organisms are found				Total
	Length groups, mm				
	4.0—5.1	4.7—5.7	6.0—6.9	7.0—9.3	
Calanus finmarchicus:					
Copepodite st. I	—	—	—	2	2
Calanus and *Metridia:*					
Nauplii	23	19	9	3	54
Copepod eggs	1	1	—	—	2
Larvae of mussels	—	2	1	—	3
Unrecognizable	25	1	1	—	27
Total number of cod larvae examined	46	21	10	3	80

TABLE 15.

Number of food organisms for cod larvae in vertical hauls with Nansen net 8/72 in the West Fjord, April—May 1947.

St. No.	Date	Depth	Large org.	Small org.
108	April 22.	50—0	4 867	8 300
110	» 24.	50—0	5 924	11 974
111	» 24.	50—0	8 833	13 100
112	» 25.	25—0	11 700	21 350
113	» 25.	50—0	5 475	5 500
114	» 25.	50—0	4 433	6.900
115	» 25.	50—0	1 155	3 670
116	» 25.	50—0	8 000	26 200
117	» 25.	50—0	470	2 010
118	» 25.	50—0	405	860
131	May 5.	50—0	11 500	4 850
142	» 7.	50—0	17 400	5 000
143	» 7.	25—0	19 450	13 660
144	» 8.	25—0	62 750	10 900
145	» 8.	25—0	66 350	1 650 (13 500 belov 25 m)
146	» 8.	25—0	36 400	5 100 (10 000 below 25 m)
147	» 8.	25—0	6 930	3 480 (7 400 below 25 m)
148	» 8.	50—0	5 850	6 710

TABLE 16.

Number of food organisms for cod larvae per cubic meter of sea water in the Austnes Fjord, April—May 1937. Plankton sampler hauls.

Depth	April 23.		April 30.		May 5.	
	Large org.	Small org.	Large org.	Small org.	Large org.	Small org.
5	1 721	11 514	—	—	—	—
10	4 337	6 508	5 551	11 821	5 824	5 708
15[1]	—	—	—	—	6 016	4 780
20	—	—	—	—	6 331	5 100
25	3 161	25 019	2 200	14 000	3 611	7 863
30	—	—	—	—	3 662	25 680
38	—	—	—	—	1 354	11 077
50	100	2 592	—	—	—	—
60	—	—	1 395	2 124	—	—
25—0	—	—	6 892	13 207	—	—
60—25	—	—	1 025	3 358	—	—
25—0[2]	—	—	46 700	18 250	—	—
60—25[2]	—	—	3 900	11 900	—	—

[1] Pump.

[2] Nansen net 8/72, per haul.

the feeding goes on continuously, and sufficient food is found within one liter of seawater.

As the larvae grow up, the need for food will increase correspondingly, but the rate of action will also be higher.

The growth of the larvae may possibly be influenced by the quality of the food, as well as by temperature, concentration of plant plankton, by the alkalinity of the sea water (PH) and by other factors.

Different plankton organisms, such as medusae, glass worms and small fishes will undoubtedly take their part of the cod larvae. (See RUSSELL 1935).

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